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Dissertation Summary

High-Precision Optical Interferometry and Application to Be Stars

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This dissertation presents a new technique for calibrating optical long-baseline interferometric observations that are obtained simultaneously in a number of spectral channels. For certain classes of objects, such as emission-line sources or binary systems, the new technique allows the calibration corrections and source characteristics to be obtained from the observations of a program star alone. This is because for such sources, the parameters describing the characteristics of the source have a different functional dependence than the calibration parameters.

The new calibration method is applied to long-baseline interferometric observations of four non-supergiant B-type stars with Hα emission lines, which are also known as classical Be stars. The Hα emission associated with these stars is also known to be the strongest line emission, and therefore it is an excellent probe of the shape and extent of the Hα-emitting circumstellar region. The observations presented in this dissertation were obtained with the Navy Prototype Optical Interferometer,[1] which utilizes measurements obtained simultaneously in many spectral channels covering a wide spectral range. The alignment of the spectral channels was such that the Hα emission was located in one or two spectral channels, and therefore it was possible to use the measurements from the continuum channels to derive the calibration corrections, which in turn were applied to the interferometric observables associated with the Hα emission.

Circularly symmetric and elliptical Gaussian models were fitted to the calibrated observations in Hα. Models with uniform brightness distributions were also successfully fitted. Because of the limited (u, v)-plane coverage, it is was not possible to preferentially choose one set of models over the other. For consistency (and compatibility) with the already published interferometric results in the literature, the elliptical Gaussian models were chosen as the representative models describing the angular size and the apparent ellipticity of the circumstellar regions. In at least one of the stars analyzed, a signature indicative of a circumstellar disk that is not concentric with the central star was detected. Possible causes are discussed, and these range from the presence of one-armed density waves in the disk to a simple rotation signature.

To expand the data set, thereby making correlations more apparent, the model parameters for the four Be stars investigated in this dissertation were combined with three Be stars from the study of Quirrenbach et al. (1997, ApJ, 479, 477). After accounting for the different distances to the sources and the different stellar continuum flux levels (with respect to which the Hα emission is typically measured), it was possible to study the relationship between the net Hα emission (in ergs s^{-1}) and the physical extent (in m) of the Hα-emitting circumstellar region. For the first time, a clear dependence of the net Hα emission on the extent of the circumstellar region is demonstrated (see Fig. 1). These results are consistent with an optically thick line emission that is directly proportional to the effective area of the emitting disk. Within the small sample of stars considered in this analysis, no clear dependence on the spectral type or stellar rotation is established, although the results do suggest that hotter stars might have more extended Hα-emitting regions.

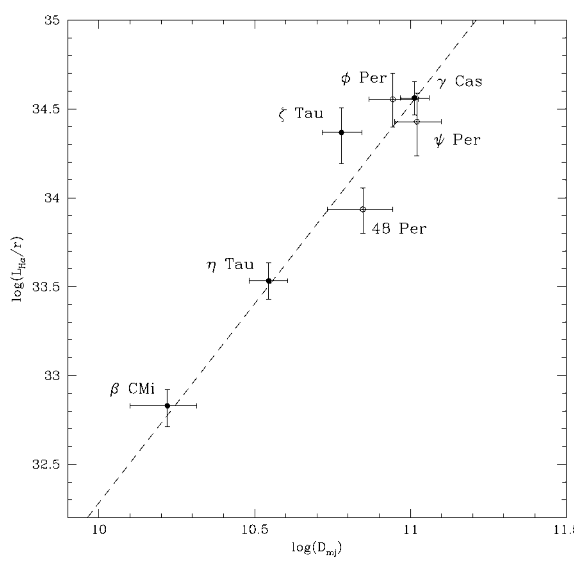

Fig. 1.—log-log plot of the Hα luminosity (in ergs s^{-1}), corrected for the projection effect (through the division by the axial ratio r), as a function of the size (in m) of the major axis of the disk. *Filled circles*: stars observed with the NPOI; *open circles*: stars observed with the Mark III interferometer (Quirrenbach et al. 1997, ApJ, 479, 477). A linear fit in the log-log plot produces a best-fit slope of 2.24 ± 0.26 (*dashed line*) consistent with an optically thick Hα emission from a geometrically thin disk of a relatively constant surface brightness.

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